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Avian Habitat Use of Upland Forests in Southeast Minnesota's Blufflands

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Introduction

Forested habitats in the Upper Midwest have been greatly reduced since settlement. More than 99% of original savanna-woodland has been lost or degraded (Nuzzo 1985), while mesic forests have declined by 20-90% and are now restricted to about 14% of the landscape (Ricketts et al. 1999). Both model results and empirical data suggest that when fragmentation reduces the amount of a given habitat to <30% of the landscape, species associated with that habitat experience sharp declines (Andrén 1994). To preserve forest biodiversity in the Upper Midwest, conservationists have begun to focus increased attention on the Driftless Area, where 30-50% of the landscape remains forested (Knutson et al. 2001).

The Driftless Area Ecoregion (a.k.a. the Paleozoic Plateau or Blufflands) covers 42,000 km^2 in southeastern Minnesota, northeastern Iowa, and southwestern Wisconsin, as well as a very small portion of northwest Illinois (McNab and Avers 1994). This ecoregion is so-named because it was not covered by glaciers during the latter part of the Pleistocene epoch and has a unique geology characterized by highly dissected upland plateaus, abundant rock outcroppings, and deeply cut valleys (Prior 1991).

Knutson et al. (2001) recommended that because a relatively large percentage of the Driftless Area remains forested, the conservation potential is relatively high there for forest birds compared to other areas in the Upper Midwest. Southeastern Minnesota’s Blufflands contain 54% of the avian Species of Greatest Conservation Need (SGCN) identified in the MN DNR Comprehensive Wildlife Conservation Strategy (CWCS; 2005). Upland deciduous hardwood forests there have been reduced in area by less than six percent since the 1890’s. Although the overall extent of forest cover suggests much potential for conserving forest bird diversity, native ecosystems in this topographically dissected area have been greatly altered since settlement. Presettlement oak-dominated (*Quercus* spp.) forests have been highly fragmented and degraded as the result of fire suppression, conversion to agriculture, silvicultural practices, and increases in ungulate grazer populations (Lorimer 1984, Nuzzo 1985, Abrams 1992). In fact, habitat degradation is the primary threat to SGCN in the Blufflands subsection. Of particular concern in forest remnants is a shift toward more closed canopy stands and a higher proportion of climax species such as sugar maple (*Acer saccharum*) and basswood (*Tilia Americana*). Recent USDA Forest Service inventories (http://fia.fs.fed.us/) provide evidence of oak declines throughout a sizeable portion of the Driftless Area and widespread failure of oaks to regenerate, reflecting trends over much of this species range (McShea and Healy 2002).

For birds, evidence suggests that changes from oak- to maple-dominated forests may have adverse impacts for resident and long-distance migrant species, woodpeckers, and bark-gleaners (Rodewald and Abrams 2002, Rodewald 2003). Particularly sensitive to such changes are foliage-gleaners and ground-gleaners, the predominant foraging strategies represented on the list of bird SGCN that was developed in the CWCS (2005) for the Blufflands subsection in the Driftless Area. Also of concern, though less well-studied, are impacts on avian communities resulting from increases in invasive species, such as garlic mustard (*Alliaria petiolata*), buckthorn (*Rhamnus* spp.), and honeysuckle (*Lonicera* spp.).

The conservation value of Blufflands forests is affected not only by within-stand dynamics, but also by shifts in the composition of the surrounding landscape matrix. The influence of the surrounding landscape on ecological patterns and processes in nature reserves is inversely correlated with reserve size (Saunders et al. 1991), and relatively small reserves predominate in this region. Moreover, demographics there are changing rapidly, with a growing number out-of-state landowners and an increase in development pressure. Properties bordering parks and natural areas are particularly attractive targets for residential and second home construction in many areas (Miller and Hobbs 2002). Thus, public land managers must contend with new challenges stemming from activities on adjacent properties in addition to those associated with traditional land uses such as agriculture or silviculture. To further complicate matters, research suggests that avian response to landscape patterns in the Driftless Area generally may deviate from responses observed in other eastern and Midwestern forests (Knutson et al. 2004, Miller et al. 2004), perhaps because forests in this region are naturally fragmented as a function of topography. Whatever the reason, this makes extrapolation from studies conducted in other regions somewhat tenuous.

Given the potential of Minnesota's Blufflands in particular and the Driftless Area generally in terms of avian conservation, there is an urgent need to develop strategies and best management practices that will ensure conditions that will maintain viable populations of forest bird species. Such strategies and practices must be based on scientifically rigorous assessments of forest conditions and habitat use by birds on both public and private lands.

Objectives

The *overall goal* of this project was to improve knowledge regarding the distribution of forest birds and their habitats in the Blufflands subsection of southeastern Minnesota, with special emphasis on SGCN. The specific goals of this project were as follows:

1. *Establish a suite of approximately 10 study sites on public and private lands in southeast Minnesota.*
2. *Quantify the relationship between habitat use by forest birds (as measured by species occurrence/density) and forest structure/composition.*

3. *Quantify the influence of the surrounding landscape matrix on habitat use by forest birds once variation due to local habitat conditions has been explained.*
4. *Examine the extent to which measures derived from remote sensing (e.g., canopy cover, forest area) can serve as indicators of the abundance of bird species with varying habitat requirements.*

Methods

Site Selection

In the summer of 2007, we relocated point count stations (n=72) established on wooded sites and surveyed by Niemi et al. (1998; hereafter, Survey I) in southeastern Minnesota. These stations were located in state parks, forests, and wildlife management areas in Goodhue, Wabasha, Winona, Fillmore, and Houston counties (Fig. 1, Table 1). We excluded stations occurring in floodplains and included only those considered to be within the Driftless Area. We also restricted our surveys to those stations which could be relocated with a fair measure of certainty on the basis of UTM coordinates, field markings, and field maps originally recorded during the surveys by Niemi et al. (2003). All stations were at least 250m apart and no station was located within 50m of a forest/non-forest edge.

Vegetation Surveys

We measured local habitat features within a 100-m radius at each point count station (Table 2) following the methods employed by Niemi et al. (unpublished). These methods were designed to collect information on habitat structure and plant composition in an efficient manner (Niemi, personal communication), which was especially important given the number and widespread dispersion of count stations. The canopy height within 100 m of the station was visually estimated. The density of trees (>2.5 cm dbh) and shrubs (all woody plants <2.5 cm dbh) were quantified by counting individuals in each category within a 10-m radius of the station, then assigning these tallies to 1 of 5 categories (Table 2). Percent canopy cover, subcanopy cover, understory cover, and ground cover within a 100-m radius of the station were each estimated in increments of 10 (i.e., 100%, 90%, 80%, etc.). We measured foliage height diversity in each cardinal direction from the count station by estimating percent cover in increments of 10 for each of 7 height classes (Table 2). We listed up to five tree species and five shrub species within 100 m of the station, beginning with the most abundant species. Special features within the 100-m radius were also noted (Table 2).

Landscape Features

We characterized land use and land cover in the landscapes surrounding count stations using grayscale orthophotos taken in 1991 (1-m resolution at 1:12,000 scale for 3.75-minute quarter quadrangles; USGS National Agriculture Imagery Program Digital Ortho-rectified Images) and color orthophotos taken in 2004 (1-m resolution at 1:62,500 scale quadrangles; FSA National Agriculture Imagery Program). These were digitized and quantified at three spatial scales using a geographic information system (ArcGIS 9.2). To quantify landscape factors that most directly affect habitat use at finer scales, we categorized land cover within 200m of each station into 6 percentage classes: deciduous forest, coniferous forest, open canopy, agriculture, percent open water, and percent built. We also quantified the percentage of forest and non-forest cover at successive 2-km intervals in bands extending from the count stations. Among-station variance reached an asymptote at 6 km, indicating that beyond this distance there was little remaining variability in the proportion of these two cover classes (Haire et al. 2000, Dunford and Freemark 2005). We therefore used 6 km as our outer bound for measuring percent forest; we also quantified percent forest within 1km to serve as an intermediate measure. In 2007, we ground-truthed these classifications and made corrections as necessary.

Avian Surveys

We conducted unlimited distance point counts at each of the count stations twice during the breeding season between May 30th and July 15th in 2007 (hereafter, Survey II) using standard point count methodology (Ralph et al. 1993, 1995; Howe et al. 1997). Surveys were conducted between sunrise and 1000 h, and no surveys were conducted during periods of rainfall, high winds (>20 km/hr) or fog. All counts were initiated immediately after the observer arrived at each station and continued for 10 min. All birds were identified visually and/or aurally; fly-overs were noted but not included in the final counts. To reduce observer bias, the two surveys at each station were conducted by different observers.

Data Analyses

For the purposes of this report, we excluded flyovers, nocturnal and crepuscular birds, aerial insectivores, upland game birds, raptors, shorebirds, and waterfowl because our methods were not appropriate for censusing them (Bibby et al. 1992). The maximum number of individuals recorded on a survey at a given site was used to estimate the relative abundance of each species at that site. We used the maximum number of individuals rather than the average because averaging values would produce a misleading estimate for species that were not present or not singing during one or more surveys. To facilitate comparisons with the data collected by

Niemi et al. (2003), our data summaries and analyses included only birds detected within 100 m of count stations. For the most part, our analyses focus on 2007 data and those collected during Survey I (1997-98) because after 1997 no additional count stations were added and using data from these years provide a 10-year interval for comparison. We do, however, compare our 2007 data with those collected over the entire period (1997-2001, excluding 1995-96 because not all survey points were established) during which surveys were conducted by Niemi et al. (2003).

Because relative abundance at a given point was typically low (1 or sometimes 2 individuals) for the majority of species, we conducted a number of analyses using presence/absence data. We first tested whether the probability of occurrence for each species was the same between surveys by constructing a contingency table quantifying the number of presences and absences at stations in each survey (Table 4). Let N be the number of location points. Here, θ_{X11}, θ_{X12}, θ_{X21}, θ_{X22} denote the unknown cell probabilities for the table with the sum of these probabilities equal to 1. The sum $\theta_{X1.} = \theta_{X11} + \theta_{X12}$ is the marginal probability of a presence of species X in Survey I and $\theta_{X.1} = \theta_{X11} + \theta_{X21}$ is the marginal probability of a presence of species X in year Survey II. Our null hypothesis was that H_0: $\theta_{X1.} = \theta_{X.1}$ which is equivalent to $\theta_{X12} = \theta_{X21}$. We used McNemar's test statistic $[(X_{12} - X_{22})^2 / (X_{12} + X_{22})]$ to test this hypothesis (Sprent and Smeeton 2001, Gibbons and Chakraborti 2003). Because McNemar's test requires large values for $(X_{12} + X_{22})$ to approximate the chi-square distribution, we performed a randomization test of McNemar's test statistic keeping column and row means equal instead of assuming the Chi-square approximation. McNemar tests were conducted to compare surveys conducted from 1997-1998 (Survey I) and 1997-2001 with Survey II.

We developed generalized linear models using presence/absence data (Proc Logistic, SAS Institute 2003) from Survey I for species which occurred at $\geq$10% and $\leq$90% of the count stations. We considered local habitat to be the most parsimonious explanation for variability in species distributions and developed our initial models using combinations of local habitat variables selected *a priori* based on each species ecological and life-history traits (Poole and Gill 2002). We then added variables measured at the 200-m scale to see if the performance of local-habitat models was improved. Next we added the variables describing the amount of forest cover at the 1-km and at 6-km scales, respectively. Proportional variables were arcsine transformed prior to the analyses.

We used the Akaike Information Criterion (AIC) to assess each model's performance and ultimately to select the 'best' models for each species. In addition to evaluating models based on AIC (i.e., lowest AIC value = 'best'; Burnham and Anderson 1998), we also evaluated the models using Akaiki weights, w_i , which indicate the strength of evidence for the i model. The w_i is interpreted as the probability that model i is the best model in the set being considered (Burnham and Anderson 1998). For each species, only models with w_i >0.1 were considered.

To determine if spatial autocorrelation was an issue in our data, we calculated Moran's I using R (R Program Development Group 2004) and the residuals from the best model for each species. This allowed us to gauge the degree of autocorrelation in each model and to identify the contributing sites (Legendre and Legendre 1998). For species with autocorrelated residuals, we grouped count stations by site and fit generalized linear models with a random intercept for each site (Proc Glimmix, SAS Institute 2003).

We evaluated the ability of models to discriminate between presences and absences using data from Survey II. We computed Receiver Operating Characteristic (ROC) curves (Pearce and Ferrier 2000) for every candidate model for each species using R (R Development Core Team 2004). Whereas traditional measures of model discrimination rely on an arbitrary value to translate predicted probabilities into presence and absence (typically 0.5), ROC curves involve plotting each pair of true positive and false positive proportions for every possible value between 0 and 1 (Pearce and Ferrier 2000). The area under the ROC curve can be interpreted as the probability that a model will correctly discriminate a true presence and true absence drawn at random. A value of 0.5 indicates model performance no better than random.

Results

We detected 3373 individual birds and 40 species in 2007, including 8 SGCN (Table 5). We excluded two forest songbirds, the Red-eyed Vireo (*Vireo olivaceus*) and the Yellow-throated Vireo (*Vireo flavifrons*), from our data summaries and analyses because we doubted the accuracy of the survey data for these two species.

Four species that were observed at these count stations during Survey I were not detected in 2007, including one SGCN – the Winter Wren (Table 5). Five SGCN were detected at more points in Survey II compared to Survey I, and the increase was substantial for the Acadian Flycatcher, Blue-Winged Warbler, and Wood Thrush. In addition to the Winter Wren, three SGCN were detected at fewer stations in 2007 – the Cerulean Warbler, Least Flycatcher, and Yellow-bellied Sapsucker (Table 5). Among the remaining species, several increased dramatically in terms of the number of points at which they were detected. Aside from the four species not detected at all, only one species (the Downy Woodpecker) exhibited a substantial decline (Table 5).

McNemar tests showed significant changes for 20 species from Survey I to Survey II in terms of occurrence at count stations – all positive with the exception of the Downy Woodpecker (Table 6). However, only four species showed consistent trends when comparing data from

Survey I and the period 1997-2001 with the 2007 data. The direction of change was different for only one species, the American Robin, when comparing Survey I data with those collected in 2007 versus data from 1997-2001 compared to 2007 data. Eight species were detected at significantly fewer stations during the 1997-2001 period compared to 2007 (Table 6).

Twenty-six species met our criteria for conducting logistic regression analyses. Of these, models for 19 species performed better than intercept-only models, based on AIC values (Table 7). In most cases, the predictive ability of most models was not much better than random, based on the ROC curves. The lone exception was the model for the Acadian Flycatcher, a SGCN, which had fairly strong predictive power when tested with the 2007 data (Table 7).

Models that only included variables derived from remotely-sensed data performed somewhat better in terms of their predictive ability (Table 8). This was especially the case for two SGCN, the Eastern Wood-Pewee and Cerulean Warbler, and the Northern Cardinal.

Discussion

Woodpeckers and species that glean insects from bark, foliage, or on the ground are thought to be most sensitive to the shifts in tree composition that we observed (Rodewald and Abrams 2002, Rodewald 2003). Species that nest low in vegetation or on the ground could be expected to respond adversely to declines in understory species and increases in ‘disturbance’ species, and possibly to increases in garlic mustard – either indirectly through trophic interactions or directly through changes in nesting habitat. Yet, comparisons of the data from Survey I and II fail to support these contentions and for many species trends were just the opposite.

The Winter Wren, a SGCN which is associated with old growth forests and gleans on the ground or in low vegetation (Hejl et al. 2002), was detected in Survey I but not in 2007. Yet five SGCN were detected at more count stations in Survey II than in the preceding decade, and the increase was substantial for the Blue-winged Warbler – a species associated with open habitats and dense understories (Gill et al. 2001) – and the Wood Thrush, a ground forager that is typically found in areas with dense shrubs and moderate sub-canopy (Roth et al. 1996). The number of points at which the Acadian Flycatcher was detected more than doubled, although the number of points was still relatively low. This species is a leaf gleaner that nests in the sub-canopy.

Numerous other species showed dramatic increases, contrary to the predictions noted above. The Eastern Towhee is a ground and foliage gleaner that prefers dense shrubs, small trees, and open-canopy situations (Greenlaw 1996), and the number of points at which it was detected more than doubled. The Cerulean Warbler and Least Flycatcher, both SGCN and foliage gleaners, appeared at only a few points in Survey I and even fewer in Survey II, while the bark-gleaning Yellow-bellied Sapsucker declined to a relatively lesser degree. Among the other species, aside from the handful that were not detected in 2007, the only species to experience dramatic declines was the Downy Woodpecker. Yet two other woodpeckers, the Pileated and Red-bellied, increased dramatically.

McNemar tests appeared to corroborate the above patterns; the only species showing significantly fewer occurrences between Survey I and Survey II was the Downy Woodpecker. For some species, such as the Cerulean Warbler and Least Flycatcher, a small sample size likely caused their declines to be statistically non-significant. However, when the entire survey period 1997-2001 is considered, a number of other species had significantly fewer occurrences than in

2007. This raises the issue of reliability for patterns detected in surveys of short duration (Wiens 1981). Niemi and his colleagues (1998) noted variability in trends from their earlier surveys that they attributed to factors other than habitat changes, and found that local trends did not necessarily parallel regional patterns. The differences which are apparent when comparing just the 1997-1998 data with Survey II vs. comparing the larger dataset (1997-2001) with the 2007 data underscores the inherent variability in distributional data for birds over time. It is also worth noting that surveys in 1997-1998 were conducted once per year, whereas surveys in 2007 were conducted twice during the breeding season. It is possible that some species were missed in the earlier surveys because they were not present or were not singing on a particular date. These points should not be construed to mean that surveys of relatively short duration are not useful, but rather that they should be repeated at regular intervals whenever possible.

The predictive ability of our models was not better than random in most cases, based on evaluations with the 2007 data. There are several possible explanations for this result. It may be that forested areas in southeastern Minnesota are relatively homogenous compared to other parts of the state (Niemi, personal communication). It may also be a function of the scale at which local habitat variables were estimated. Visually estimating canopy, subcanopy, and shrub cover over a 100-m radius circle from a single center-point is challenging, to say the least, particularly when vegetation is dense and visibility is limited. Models based on similar data in Iowa's Driftless Area performed better for a number of species. There, we estimated local habitat variables over a 50-m radius circle using a number of systematically distributed subplots.

In the Minnesota study, the model which performed the best (Acadian Flycatcher) included only broad-scale variables derived from remotely sensed data. Similarly, the predictive capacity of models for several species was improved substantially by including only landscape variables. This result could provide support for either of the two possible explanations noted above. The superior performance of models comprising only landscape variables may reflect the relatively higher amount of variability in the areas surrounding count stations compared to that within 100 m of the stations. Alternatively, the improved performance may be a function of inadequate sampling at the local-habitat scale.

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Table 1. Locations by county and management unit of point count stations in southeast Minnesota's Driftless Area surveyed by Niemi et al. (1998; Survey I) and in 2007 (Survey II).

County	**Unit**	**Number of Stations**
Goodhue	State Forest	15
Wabasha	State Forest	16
Winona	State Forest	3
	Whitewater WMA	3
	Whitewater State Park	3
	Great River Bluffs State Park	2
Fillmore	State Forest	13
Houston	State Forest	15
	Beaver Creek Valley State Park	2
	Total Count Stations	72

Table 2. Categories for tree density, shrub density, and special features measured at point count stations in southeastern Minnesota’s Driftless Area.

Feature Class	**Categories**
Tree Density (within 10-m radius of station)	None
	<5
	6 to 20
	21 to 40
	>40
Shrub Density (within 10-m radius of station)	<10
	11-100
	101-500
	501-1000
	>1000
Foliage Height Diversity (within 100-m radius of station)	>35 m
	20-35 m
	10-20 m
	5-10 m
	2-5 m
	0.5-2 m
	0.1-0.5 m
	<0.1 m
Special feature (within 100-m radius of station)	Beaver flooding
	Large downed logs
	Small openings
	Snags
	Wetland pocket
	Woodland pond
	Natural opening
	Rock outcrop
	Residual hardwood trees*
	Residual conifer trees*
	Residual patches

* Individuals beyond a 10-m radius from the count station

Table 3. Land-cover classes used to characterize the landscapes surrounding point count stations in southeastern Minnesota's Driftless Area for Survey I and Survey II.

Cover Classes	**Description**
200-m Scale	
Deciduous forest	Closed forests consisting primarily of broad-leaved deciduous tree species (e.g. oak, hickory, maple, and basswood).
Coniferous forest	Closed forests consisting primarily of evergreen trees (e.g. pine and cedar plantations).
Canopy openings	Gaps in the forest canopy created by natural tree falls, primitive roads and trails (this also may include areas clear-cut for forest management).
Agriculture	Areas of row crops (e.g. corn and small grains), pasture, hay fields and old fields (this includes transition areas between forest and grasslands).
Open water	Includes areas of water open to the sky (e.g. large rivers, lakes and ponds).
Built areas	This includes any area using man-made materials or cleared by heavy machinery (e.g. buildings, paved roads, quarries, and forest cleared for development).
1- and 6-km Scales	
Forest	Closed forest consisting of both deciduous and coniferous forest.

Table 4. Contingency table used to test whether the probability of occurrence for each species at N count stations was the same between Survey I and Survey II. X_{11} is the number of stations where species X was present in both surveys, X_{22} is the number of stations where the species was absent in both surveys, X_{12} is the number of stations where the species was present in Survey I but absent in Survey II, and X_{21} is the number of stations where the species was absent in Survey I but present in Survey II.

	Survey II		
Survey I	Presence	Absence	Total
Presence	X_{11}	X_{12}	$X_{11} + X_{12} = X_{1.}$
Absence	X_{21}	X_{22}	$X_{21} + X_{22} = X_{2.}$
Total	$X_{11} + X_{21} = X_{.1}$	$X_{12} + X_{22} = X_{.2}$	N

Table 5. The percentage of count stations (n=72) where bird species were detected by Niemi et al. (1998; Survey I) and in 2007 (Survey II) in the Driftless Area of southeastern Minnesota.

Common Name	**Scientific Name**	**Maximum Abundance**	**% Total Abundance**	**% Survey I points**	**% Survey II points**
Acadian Flycatcher*	*Empidonax virescens*	5	0.01	3	7
American Crow	*Corvus brachyrhynchos*	23	0.02	15	56
American Goldfinch	*Carduelis tristis*	24	0.03	22	58
American Redstart	*Setophaga ruticilla*	59	0.06	31	54
American Robin	*Turdus migratorius*	31	0.03	14	35
Baltimore Oriole	*Icterus galbula*	0	0.00	7	0
Black-capped Chickadee	*Poecile atricapillus*	45	0.05	46	60
Blue-gray Gnatcatcher	*Polioptila caerulea*	88	0.09	72	82
Brown-headed Cowbird	*Molothrus ater*	68	0.07	60	61
Blue Jay	*Cyanocitta cristata*	13	0.01	24	51
Blue-winged Warbler*	*Vermivora pinus*	12	0.01	3	21
Cedar Waxwing	*Bombycilla cedrorum*	0	0.00	21	0
Cerulean Warbler*	*Dendroica cerulea*	3	<0.01	10	6
Chipping Sparrow	*Spizella passerina*	6	0.01	13	14
Common Yellowthroat	*Geothlypis trichas*	19	0.02	6	32
Downy Woodpecker	*Picoides pubescens*	7	0.01	28	10
Eastern Phoebe	*Sayornis phoebe*	2	<0.01	1	8
Eastern Towhee	*Pipilo erythrophthalmus*	22	0.02	25	53
Eastern Wood-pewee*	*Pipilo erythrophthalmus*	72	0.08	86	93
Field Sparrow	*Spizella pusilla*	7	0.01	1	19
Great-crested Flycatcher	*Myiarchus crinitus*	15	0.02	38	32
Gray Catbird	*Dumetella carolinensis*	25	0.03	18	38
Hairy Woodpecker	*Picoides villosus*	29	0.03	11	49
House Wren	*Troglodytes aedon*	9	0.01	11	22
Indigo Bunting	*Passerina cyanea*	31	0.03	25	50
Least Flycatcher*	*Empidonax minimus*	1	<0.01	3	1
Mourning Dove	*Zenaida macroura*	2	<0.01	3	22

Northern Cardinal	*Cardinalis cardinalis*	42	0.04	31	74
Northern Flicker	*Colaptes auratus*	1	<0.01	0	8
Ovenbird*	*Seiurus aurocapilla*	77	0.08	76	86
Pileated Woodpecker	*Dryocopus pileatus*	3	<0.01	4	28
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	17	0.02	36	43
Red-bellied Woodpecker	*Melanerpes carolinus*	15	0.02	15	49
Ruby-throated Hummingbird	*Archilochus colubris*	5	0.01	14	18
Scarlet Tanager	*Piranga olivacea*	37	0.04	39	51
Song Sparrow	*Melospiza melodia*	14	0.01	3	31
Tufted Titmouse	*Baeolophus bicolor*	3	<0.01	3	4
Veery*	*Catharus fuscescens*	3	<0.01	4	4
Warbling Vireo	*Vireo gilvus*	0	0.00	1	0
White-breasted Nuthatch	*Sitta carolinensis*	12	0.01	61	75
Winter Wren*	*Troglodytes troglodytes*	0	0.00	6	0
Wood Thrush*	*Hylocichla mustelina*	11	0.01	10	29
Yellow-billed Cuckoo	*Coccyzus americanus*	5	0.01	0	7
Yellow-bellied Sapsucker*	*Sphyrapicus varius*	13	0.01	36	31

* Bird species in greatest conservation need in the Blufflands subsection of southeast Minnesota’s Driftless Area (Phannmuller et al. 2006).

Table 6. Species lost and gained at individual point count stations (n=72) between the 1995-2001 surveys (Niemi et al. 2003) and Survey II, and between Survey I and Survey II in the Driftless Area of southeastern Minnesota. McNemar tests were conducted on presence/absences data from all stations and the direction of change is included for results with p-values ≤ 0.05. Only species with that exhibited statistically significant change are included. Bold type indicates species with consistent change for both comparisons.

		1995-2001 and 2007		**1997-98 and 2007**	
Common Name	**SPECIES**	**p_value**	**Change**	**p_value**	**Change**
American Crow	AMCR	0.210		0.001	+
American Goldfinch	AMGO	0.181		0.000	+
American Redstart	AMRE	0.511		0.002	+
American Robin	AMRO	0.002	-	0.001	+
Baltimore Oriole	BAOR	0.000	-	0.066	
Brown-headed Cowbird	BHCO	0.000	-	1.000	
Blue Jay	BLJA	1.000		0.002	+
Blue-winged Warbler	BWWA	0.988		0.001	+
Common Yellowthroat	COYE	**0.004**	+	**0.000**	**+**
Downy Woodpecker	DOWO	**0.000**	**-**	**0.011**	**-**
Eastern Towhee	EATO	0.128		0.000	+
Field Sparrow	FISP	**0.014**	+	**0.002**	**+**
Great Crested Flycatcher	GCFL	0.000	-	0.604	
Gray Catbird	GRCA	0.294		0.012	+
Hairy Woodpecker	HAWO	**0.007**	+	**0.000**	**+**
House Wren	HOWR	0.001	-	0.075	
Indigo Bunting	INBU	0.087		0.004	+
Northern Cardinal	NOCA	0.679		0.000	+
Northern Flicker	NOFL	0.992		0.037	+
Pileated Woodpecker	PIWO	0.106		0.000	+
Rose-breasted Grosbeak	RBGR	0.000	-	0.495	
Red-bellied Woodpecker	RBWO	0.084		0.000	+
Ruby-throated Hummingbird	RTHU	0.003	-	0.665	

Red-winged Blackbird	RWBL	0.154		0.000	+
Scarlet Tanager	SCTA	0.001	-	0.232	
Song Sparrow	SOSP	**0.000**	**+**	**0.000**	**+**
Wood Thrush	WOTH	0.731		0.006	+
Yellow-bellied Sapsucker	YBSA	0.001	-	0.591	

Table 7. Best models based on AIC from logistic regression analyses of bird species distributions. See METHODS and Table 2 for variable definitions.

Species	Candidate Models	*w*	ROC
Acadian Flycatcher	–Decid –Water	0.50	0.83
American Redstart	–Subcanopy +Open –1kmFor	0.52	0.55
American Robin	+Shrubden –Subcanopy +6kmFor	1.00	0.55
Black-capped Chickadee	–Subcanopy –Decid –Open	0.27	0.48
Blue-gray Gnatcatcher	–Subcanopy –Undercov +6kmFor	0.46	0.51
Blue Jay	–Open	0.39	0.33
Blue-winged Warbler	–Shrubden +Undercov	1.00	0.32
Cerulean Warbler	+Treeden –Decid	0.45	0.38
Chipping Sparrow	–Shrubden –Agric –Conif –1kmFor –6kmFor	1.00	0.52
Eastern Towhee	–Undercov –Open	0.32	0.46
Eastern Wood-Pewee	+Treeden –Shrubden –Canopy –Conif –6kmFor	0.57	0.53
Great Crested Flycatcher	+Canopy –Subcanopy –Open	0.27	0.37
Gray Catbird	–Built –Open –6kmFor	0.36	0.53
House Wren	+Treeden +Shrubden	0.31	0.45
Northern Cardinal	–AveFol2&3 +Undercov +Decid +Open –1kmFor	0.33	0.48
Red-bellied Woodpecker	–AveFol4&5 –Shrubden –6kmFor	1.00	0.49
White-breasted Nuthatch	+AveFol4&5	0.21	0.48
Wood Thrush	–Subcanopy –Undercov	0.21	0.49
Yellow-bellied Sapsucker	–Shrubden +Water –1kmFor	0.37	0.56

Table 8. Best models based on AIC from logistic regression analyses of bird species distribution using only variables derived from remotely-sensed imagery. See METHODS and Table 2 for variable definitions.

Species	**Landscape Candidate Models**	***w***	**ROC**
Acadian Flycatcher	–Decid –Water	0.50	0.83
American Redstart	+Open –1kmFor +6kmFor	0.70	0.62
American Robin	+6kmFor	1.00	0.42
Black-capped Chickadee	–Open	0.37	0.47
Blue-gray Gnatcatcher	+6kmFor	1.00	0.61
Blue Jay	–Open	0.39	0.33
Blue-winged Warbler	–Open	1.00	0.32
Cerulean Warbler	–Decid	0.47	0.52
Chipping Sparrow	–Agroc –1kmFor –6kmFor	1.00	0.51
Eastern Towhee	–Open	0.35	0.43
Eastern Wood-Pewee	–6kmFor	1.00	0.69
Great Crested Flycatcher	–Open	0.34	0.35
Gray Catbird	–Built –Open –6kmFor	0.36	0.53
Northern Cardinal	+Decid	0.28	0.66
Red-bellied Woodpecker	+Conif +Decid –6kmFor	1.00	0.53
Yellow-bellied Sapsucker	+Water –1kmFor	0.45	0.61

Figure Legend

Figure 1. Count stations in southeastern Minnesota's Driftless Area surveyed during the breeding seasons in 1995-97 by Niemi et al. (1998), and in 2007.

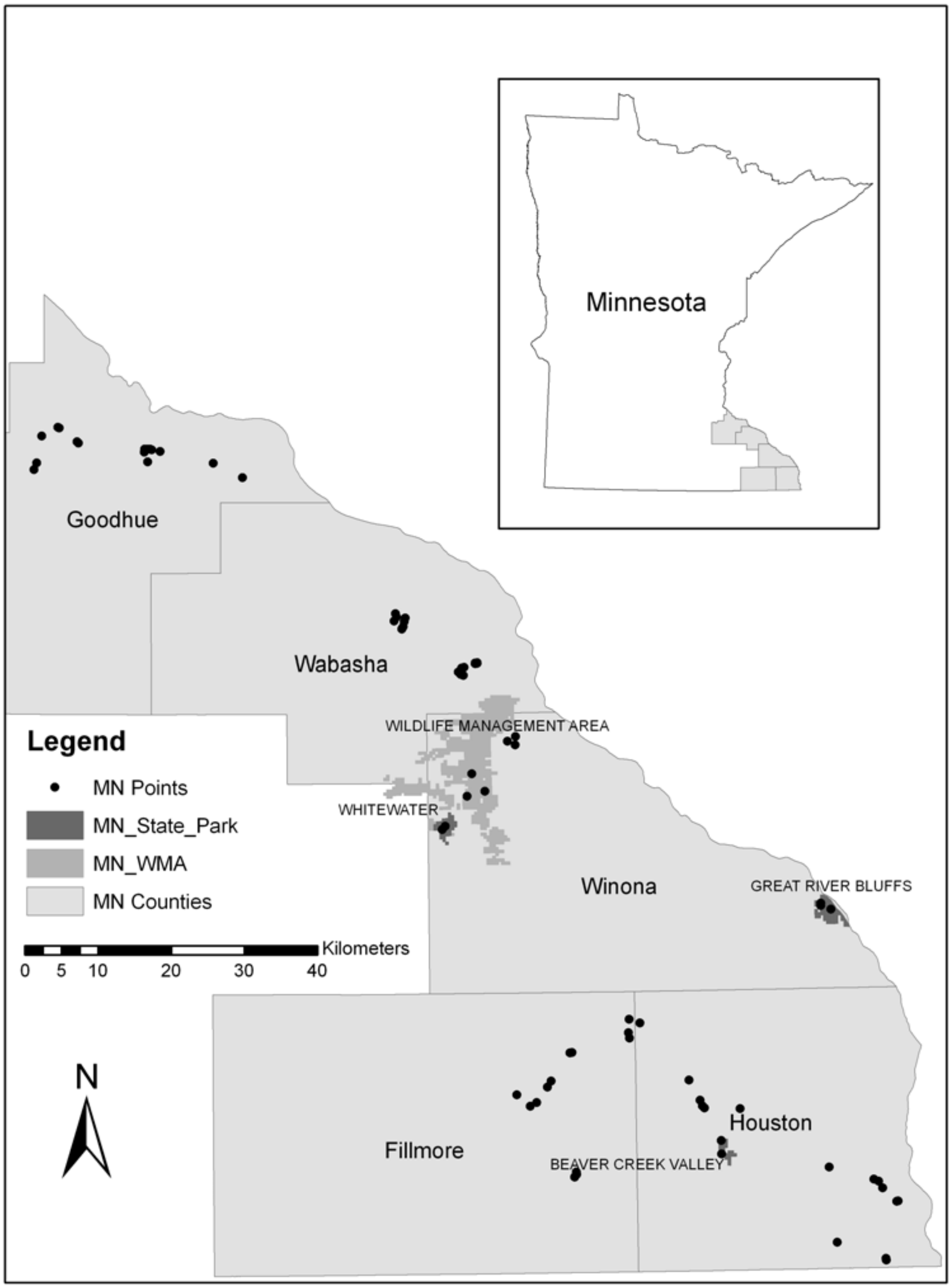
Minnesota
Goodhue
Wabasha
Winona
Fillmore
Houston
WILDLIFE MANAGEMENT AREA
WHITEWATER
GREAT RIVER BLUFFS
BEAVER CREEK VALLEY
Legend
MN Points
MN_State_Park
MN_WMA
MN Counties
Kilometers
0
5
10
20
30
40
N

Figure 1.